for bacterial affinities in some ascomycetous and sphaeropsidaceous forms, the hyphae of which are similarly very minute. It is doubtful whether far-reaching taxonomic generalizations can be based upon the 'acid-fast' staining reaction, especially as this reaction has not played a very important rôle in mycological research. There seems to be no adequate reason why the genus should not be classed, in an unqualified manner, with the Hyphomycetes, as a Mucedineous group with tendencies toward an erect Isaroid habit.

A more complete illustrated account will appear shortly in the *Botanical Gazette*.

STUDIES OF MAGNITUDES IN STAR CLUSTERS, VIII. A SUMMARY OF RESULTS BEARING ON THE STRUCTURE OF THE SIDEREAL UNIVERSE

By Harlow Shapley

Mount Wilson Solar Observatory, Carnegie Institution of Washington

Communicated by W. S. Adams, May 21, 1918

In the preceding communication of this series[1] methods were discussed for the determination of the relative distances of a considerable number of globular clusters. The methods have now been developed so as to give not only relative values but also fairly reliable absolute distances for all globular clusters, and for all variable stars of the Cepheid class for which periods and apparent magnitudes are known. A rather detailed summary of the procedure, its accuracy, and the results of a thorough application of the methods, has been given in the February issue of the *Publications of the Astronomical Society of the Pacific*. The present note will be confined to a synopsis of the more important results pertaining to the probable extent and arrangement of the sidereal system. The detailed discussion is appearing in a series of papers in the *Astrophysical Journal*, and will be separately published as *Contributions from the Mount Wilson Solar Observatory*, Nos. 151–157.

Extending to the globular clusters the work of Miss Leavitt, Hertzsprung, and Russell on the Cepheid variables of the Small Magellanic Cloud and of the galactic system, we have been able to establish beyond question the interdependence for these variables of absolute luminosity and period of light variation. By combining the apparent and absolute magnitudes, the distances and positions in space have been determined for about 140 Cepheid variables, most of which are much more distant than any objects for which parallaxes have been directly measured. Figure 1 shows their distribution.

The distances of globular clusters are of a different order of magnitude from those heretofore entering stellar investigations. Although the average naked-eye star is near as compared with many Cepheid variables, the most remote Cepheid now known is not so far away as the nearest globular cluster. The

available astronomical records contain 69 clusters that appear definitely to belong to the globular classification. Further work on very faint and distant objects will probably add a few to the present list, but within a distance of 100,000 light-years of the sun the survey appears to be complete. Keeping this limitation in mind, we may examine the collected data for signs of a general organization.

The apparent concentration of the globular systems to a southern region of the Milky Way has long been known. It now appears, upon closer investigation, that few if any typical globular clusters are to be found within 5° of the galactic plane; and, when actual positions in space are substituted for apparent positions, this suggested avoidance of the mid-galactic region reveals

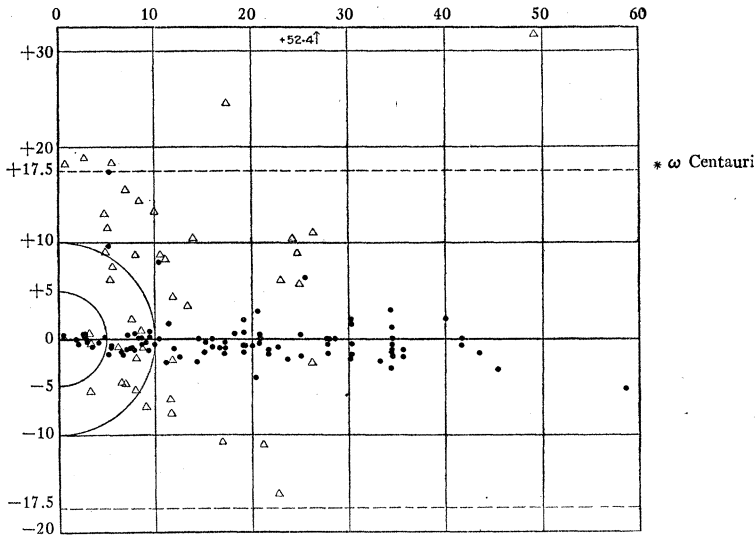


FIG. 1. DISTRIBUTION OF CEPHEID VARIABLES

The unit of distance is 100 parsecs. Ordinates are distances from the galactic plane; abscissae are projected distances in the plane. Open triangles and black dots designate, respectively, cluster-type variables and Cepheids with periods in excess of a day. The nearest globular cluster, ω Centauri, is just outside the boundary of the diagram on the right. RU Boötis, indicated by an arrow, is too far above the plane to fall within the figure. The semicircles, with radii of 500 and 1000 parsecs (π = 0″.002 and 0″.001), indicate how distant most of these variables are as compared with the average star of the tenth magnitude or brighter (π > 0″.004, Kapteyn). Between the broken horizontal lines, ±1750 parsecs, lies the equatorial galactic region devoid of globular clusters.

itself as a total absence of compact clusters from the domains of space that appear to contain most of the known sidereal bodies.

The striking distribution of globular clusters in galactic longitude is well shown in the projection of their positions on the galactic plane in figure 2. Apparently the clusters themselves form a large flattened system, the center

of which, in the galactic plane, is between 60 and 70 thousand light-years distant in the general direction of the dense star clouds of Sagittarius and Scorpio.

The projection of the positions of clusters on a plane perpendicular to the Milky Way, and parallel to the direction of this center from the sun, is illustrated in figure 3. The shaded portion of the diagram indicates the equatorial region, toward which globular clusters crowd but in which they are not found; its thickness appears to be only three or four per cent of its extent along the galactic plane.

There can be little doubt that the galactic plane defined by the faint stars and by the Milky Way clouds is also a symmetrical and fundamental plane for the system of globular clusters. In other words, the distribution of clusters shows that, notwithstanding their great dimensions, they are subordinate

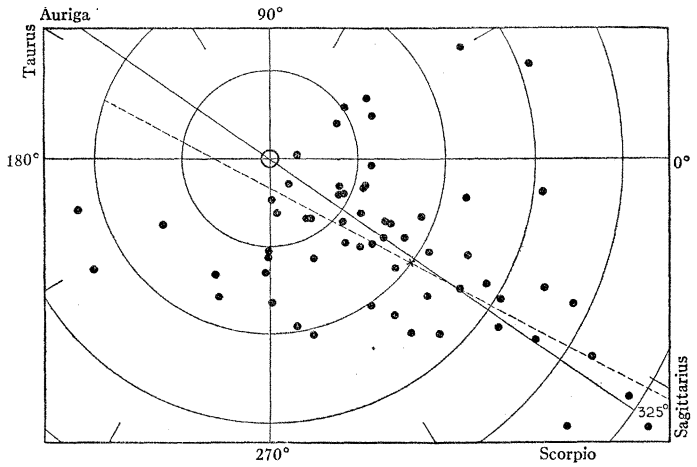


FIG. 2. THE SYSTEM OF GLOBULAR CLUSTERS PROJECTED ON THE PLANE OF THE GALAXY

The galactic longitude is indicated in the margin. The 'local system' is completely within the smallest circle, which has a radius of a thousand parsecs (3260 light-years). The larger circles, which are also heliocentric, have radii increasing by intervals of 10,000 parsecs. The dotted line indicates the suggested major axis of the system (if ellipsoidal), and the cross the adopted center. The dots are about five times the actual diameters of the clusters on this scale. Nine clusters more distant from the plane than 15,000 parsecs are not included in this diagram.

members of the far greater galactic system. Their arrangement and the relative densities of various parts of the Milky Way clouds strongly suggest that the whole sidereal system is roughly outlined by the positions of globular clusters, and that all known celestial objects—stars, nebulae, clusters—are members of a single unit.

The mean diameter of the proposed system appears to be at least 300,000 light-years; its most conspicuous feature is the equatorial segment, which apparently is thickly populated with stars throughout its whole extent. From

this viewpoint the Milky Way is mainly a phenomenon of depth; its extent, as seen from the sun, is something like three times as great in the direction of the center as in the opposite direction toward Auriga and Taurus. The testimony of the star frequencies in the Milky Way clouds does not disagree with the supposition of a remarkably eccentric position of the solar system.

Slipher's radial velocity observations of the brighter globular clusters[2] indicate that seven out of eight of those with high galactic latitudes are approaching the sun (and probably the equatorial segment) with such high velocities that, unless greatly retarded, they will have entered the dense stellar regions within an interval of time which appears to be short as compared with the probable history of a stellar system. The absence of such clusters from the

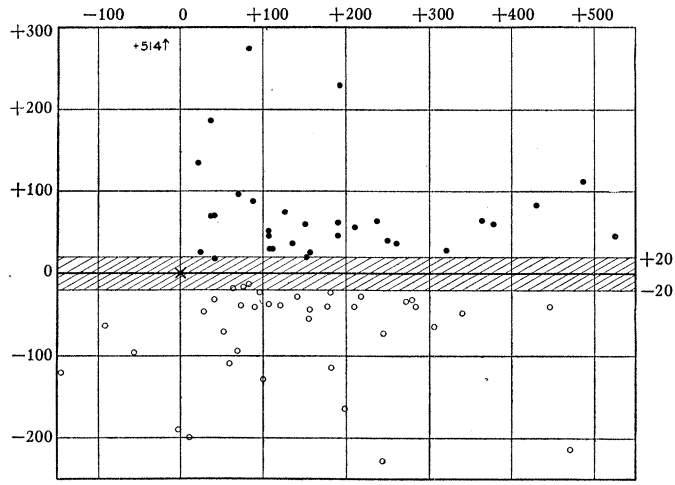


FIG. 3. PROJECTION OF THE POSITIONS OF GLOBULAR CLUSTERS ON A PLANE PERPENDICULAR TO THE GALAXY

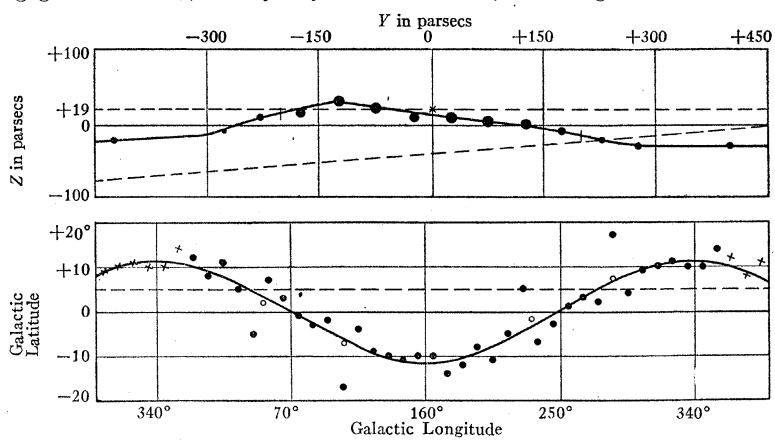
Illustrating (1) the absence of clusters from the mid-galactic region, (2) their symmetrical arrangement with respect to the Galaxy, (3) the eccentric position of the sun (the cross) with respect to the center of the system of clusters. The ordinates are distances from the galactic plane, $R \sin \beta$; the abscissae are projected distances in the direction of the center, $R \cos \beta \cos (\lambda - 325°)$. The unit of distance is 100 parsecs (326 light-years); each small square is 10,000 parsecs on a side. On this scale the actual diameter of each cluster is about one-fifth the diameter of the circles and dots. The cluster N.G.C. 4147 is outside the boundary of the diagram, as indicated by the arrow.

Galaxy thus becomes the more remarkable. The globular systems nearest the galactic plane are in general the least condensed. This result and the distribution of stars in certain open clusters suggest the possibility that upon approaching the galactic regions globular clusters may be disrupted and transformed into open galactic groups.

The galactic center as derived from the clusters is nearly at right angles to the direction of center obtained by Walkey and Charlier from statistical inves-

tigations of the brighter stars. The stars of spectral type B, according to Charlier,[3] form a flattened system of some 2000 light-years radius, which he identifies with the general stellar universe; the group is very small, however, as compared with the system now outlined by globular clusters, and we may assume instead that these B stars comprise a localized stellar organization.

To test further for the existence of a limited local cluster, situated far within the bounds of the equatorial segment and perhaps comparable in some respects with other open galactic groups, an investigation has been made of the galactic arrangement of the brighter stars. Details of this study are given in *Mount Wilson Contribution* No. 157. In brief, a verification is obtained of the presence of a local cluster, for which the following properties are indicated: (a) it contains very nearly all the B stars brighter than the seventh magnitude (the remainder appearing to be members of the intermingling and surrounding galactic field), a majority of the A stars, and large numbers of those of



FIGS. 4*a* AND 4*b*

Fig. 4*a*. (Above) Projection of the local cluster of B stars on a plane perpendicular to the Galaxy,—adapted from the data shown in Plate IV of Charlier's memoir. The inclination of the cluster's central plane to the Galaxy has been partially eliminated by Charlier. The projected center of the system of B stars, as derived by him, is at the origin of co-ordinates; the present work suggests that the central plane of the B stars is much nearer the sun (whose position is indicated by the cross) than Charlier supposed. The projection of the true galactic plane appears as a broken inclined line, and the distance of the sun and the local cluster north of it is to be noted. Short vertical lines across the curve show the limits of distance adopted for the solution represented by Fig 4*b*.

Fig. 4*b*. (Below.) Solution for the inclination of the local cluster to the galactic plane, based upon 400 stars of spectral-type B. Owing to the sun's position to the north, the central plane has a dip of 5°.

redder spectral types; (b) its central plane is not more than 30 light-years south of the sun and may be much nearer; on the other hand the true galactic plane, as defined by Cepheid variables, faint stars, and the galactic clouds, is approximately 175 light-years south of the center of the local cluster (fig. 4*a*); (c) the central plane, at least for the brighter stars, in inclined about 12° to

the galactic plane, with nodes in longitude 70° and 250° (figs. 4*a* and 4*b*); (d) the diameter is of the order of 2500 light-years.

The above results lead to a simple interpretation of star-streaming. The motion of an open cluster through the general star-fields of the equatorial segment must give rise to stellar drifts, and it is a natural assumption that the observed streaming in the neighborhood of the sun is wholly due to such a cause. According to this view, stars of Stream I belong to the large moving cluster surrounding the sun; those of Stream II belong to the galactic field. The motion of the cluster as a whole is in the galactic plane, nearly radial from the galactic center, and there is considerable evidence of internal motion within the cluster. In all the details examined, this hypothesis appears to be in agreement with the observed systematic motions of the stars.

[1] Shapley, H., these PROCEEDINGS, **3**, 1917, (479–484); *Mt. Wilson Communication*, No. 37.

[2] Slipher, V. M., *Popular Astronomy, Northfield, Minn.*, **26**, 1918, (8).

[3] Charlier, C. V. L., *Meddelanden fran Lunds Astro omiska Observatorium, Upsala*, (Ser. 2), No. 14, 1916, (1–108).

GLACIAL DEPRESSION AND POST-GLACIAL UPLIFT OF NORTHEASTERN AMERICA

BY H. L. FAIRCHILD

DEPARTMENT OF GEOLOGY, UNIVERSITY OF ROCHESTER

Communicated by J. M. Clarke, June 4, 1918

The geophysical theory of isostacy is excellently illustrated by the up and down (diastrophic) movements of northeastern America in relation to glaciation. The amount and the area of land depression beneath the ice sheet, and the land uplift subsequent to the removal of the ice, is fairly proportionate to the thickness and extent of the latest ice cap.

The fact is evident that the area covered by the latest continental ice sheet, the Labrador (Quebec) glacier, stood much beneath its present altitude, relative to sea-level, when the ice melted off; and that the recent uplift has brought the land to its present position. The evidence of the uplift is abundant; many high-level beaches and sand-plains facing the open sea and extending far up the valleys in Canada, New England and New York, with the occurrence of abundant marine fossils hundreds of feet above the ocean. These facts have been recognized for quite a century, and many observations are recorded in the geologic literature of Canada and America. But up to the present time the full amount of submergence and the extent or limits of the drowned area have not been determined beyond dispute. The full amount of the down-and-up movement has nearly always been underestimated, because the conspicuous or more evident marine features are generally of inferior and later